(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 724 340 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
21.04.1999 Bulletin 1999/16

(51) Int Cl.^{6}: **H04B 10/10**

(21) Application number: **96100980.0**

(22) Date of filing: **24.01.1996**

(54) Free space optical communication apparatus and angle adjusting method

Einrichtung zur leitungsungebundenen optischen Signalübertragung und Verfahren zur Winkeljustierung

Appareil de communication optique en espace libre et procédé d'ajustage d'angles

(84) Designated Contracting States:
DE FR GB NL

(30) Priority: **26.01.1995 JP 28922/95**

(43) Date of publication of application:
31.07.1996 Bulletin 1996/31

(73) Proprietor: **CANON KABUSHIKI KAISHA
Tokyo (JP)**

(72) Inventor: **Degura, Yasusaburo, c/o Canon K.K.
Kawasaki-shi, Kanagawa-ken (JP)**

(74) Representative: **Weser, Wolfgang et al
Dres. Weser & Martin,
Patentanwälte,
Radeckestrasse 43
81245 München (DE)**

(56) References cited:
EP-A- 0 560 315 **EP-A- 0 653 852**

- **PATENT ABSTRACTS OF JAPAN vol. 18, no. 467 (E-1599), 1994 & JP-A-06 152516 (CANON)**
- **PATENT ABSTRACTS OF JAPAN vol. 14, no. 554 (P-1140), 1990 & JP-A-02 236477 (MITSUBISHI)**

EP 0 724 340 B1

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an optical space communication apparatus provided with a function to correct an angle of transmitting light or receiving light, which performs two-way information transmission by propagating a light signal in a beam shape in a free space. Further, the invention relates to an angle adjusting method of a receiving optical system in an optical space communication system for performing communication by propagating a light signal in a free space.

Related Background Art

[0002] In conventional optical space communication apparatus, a transmission-side device transmits a signal in which a pilot signal is superimposed on a main signal (transmission signal), and a reception-side device detects the pilot signal to extract information about an angle deviation between the optical axis of a receiving optical system and the receiving light, thereby adjusting the angle upon start of transmission or correcting the angle during transmission. A generally employed method for detecting the angular deviation is one arranged in such a manner that a receiving light spot focused by the receiving optical system is guided onto a photodetector and the photodetector detects a position of the spot. The pilot signal is a signal having a frequency band different from and narrower than that of the main signal. An example of the pilot signal is a sinusoidal signal.

[0003] The photosensor employed is a PSD (Position Sensitive Detector) or a CCD (Charge Coupled Device), which demonstrates weakness with respect to the response speed when the frequency of the pilot signal is high. A method for overcoming it employs an array of plural photodiodes with fast response speed and detects differences of outputs from the photodiodes. For example, as shown in Fig. 1, photodetectors la to 1d with same characteristics are located in the four quadrants, respectively, and light intensities thereof are obtained through load impedances 2a to 2d and low limiting circuits 3a to 3d, finally obtaining a position of the receiving light spot from sums and differences of these outputs.

[0004] The reason why the pilot signal is used is that high-sensitive reception is possible because of its narrower band than that of the main signal and that the control function can be maintained even if the main signal becomes weak or even if there is no input of the main signal. Further, influence of background light can be decreased when the angular deviation is detected with the pilot signal having a certain high frequency component, different from low frequency components such as dc light.

[0005] If rain, fog, or the like decreases the light intensity on a transmission path, the detection level of the pilot signal will be lowered in the above system, which will degrade S/N ratios, being signal-to-noise ratios, and which will thus greatly affect accuracy of angular deviation information. Therefore, the system of the above type includes the low limiting circuits 3a to 3d in order to avoid degradation of the accuracy of angular deviation information.

[0006] The background light is all light other than the light transmitted from the transmission-side device, in the light entering the reception-side device. For example, the background light includes the sun light, lights of buildings, etc. However, shot noise increases in the photodiodes used as photodetectors when the background light greatly increases, for example when the direct rays of the sun are incident on the photodiodes. In that case, the shot noise is detected as multiplexed with the pilot signal. This causes a problem of erroneous angle correction when only the shot noise due to the background light exceeds the low limiting value in spite of absence of incidence of the pilot light.

[0007] An optical space communication apparatus as defined by the precharacterizing features of claim 1 as well as an angle adjusting method of a receiving optical system in an optical space communication system as defined by the precharacterizing features of claims 6 and 7, respectively, are known from the EP-A-O 560 315.

[0008] From Patent Abstracts of Japan, vol. 14, no. 554 and JP-A-2 236 477 it is known to eliminate background light noise and to obtain an accurate tracking angle error signal having a high S/N ratio by respectively multiplying the outputs of respective photodetectors by the outputs of respective variable phase shifters and giving the multiplied result to a tracking error signal arithmetic operation circuit.

[0009] From the EP-A-O 653 852 there is known an optical space communication apparatus for propagating a beam of light through free space to thereby effect communication. This apparatus includes a transmitting device for transmitting a first optical signal converted into a beam of light, an expanse angle varying device for varying the angle of expanse of the beam of light into which the first optical signal has been converted, a level varying device for varying the output level of the first optical signal, a control device for controlling the expanse angle varying device and the level varying device, and a receiving device for receiving a second optical signal converted into a beam of light.

SUMMARY OF THE INVENTION

[0010] An object of the present invention is to provide an optical space communication apparatus which can correct the angle of transmitting light or receiving light without any practical trouble even with an extreme increase of the background light, solving the above prob-

lem and a respective angle adjusting method.

[0011] In order to achieve the above object, the present invention provides according to a first aspect an optical space communication apparatus as defined in claim 1.

[0012] The optical space communication apparatus having the above configuration is arranged to multiplex the pilot signal with the main signal being the transmission signal, to convert the first electric signal thus made into the first light signal, and to transmit the light signal as adjusting the beam size to a predetermined size on the reception side. The second light signal comprising the pilot signal from the party apparatus is received by the plurality of segmental opto-electrical conversion elements to be converted into second electric signals, these electric signals are split each into two signals, the signals are let to pass the band-pass filters having the pass region comprising the frequency of the pilot signal of the party apparatus and the band-pass filters having the pass region not including the frequency of the pilot signal of the party apparatus, and the detection means detects the respective signals. Angle correction of the transmitting optical system is effected by changing the cut-off frequency of the servo system loop filter, based on these detection signals, and then two-way information transmission is performed between the transmission apparatus opposed to each other as being apart at a predetermined distance.

[0013] In order to achieve the above object the invention provides according to a second and third aspect an angle adjusting method defined in claim 6 and claim 7, respectively.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a structural drawing to show an angular deviation detecting part in the conventional example;
Fig. 2 is a structural drawing to show the optical space communication apparatus of the present invention;
Fig. 3 is a structural drawing to show the angular deviation detecting part of Fig. 2;
Fig. 4 is a structural drawing to show the angular deviation detecting part of Fig. 2; and
Fig. 5 is an explanatory drawing to illustrate band-pass filters shown in Fig. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] The optical space communication apparatus of the present invention will be explained in detail by reference to the embodiment depicted in Fig. 2 to Fig. 5.

[0016] Fig. 2 is a structural drawing to show the two-way optical space communication apparatus, in which in a light transmission unit 10 an output of a generator 12 for generating the sinusoidal pilot signal as described previously is connected to a wavelength multiplexer 11 for receiving a transmission signal and an output (first electric signal) of the multiplexer 11 is connected to an electro-optical converter 13. There are a lens system 14, a polarizing beam splitter 15, and an optical-axis angle adjustment drive mechanism 16 arranged on the optical path ahead of the electro-optical converter 13.

[0017] A beam splitter 17 is located on the optical path in the direction of reflection of the polarizing beam splitter 15. A main signal detector 18 for detecting the main signal and outputting a reception signal is placed in the direction of transmission of the beam splitter 17, and an angle deviation detector 19 is placed in the direction of reflection of the beam splitter 17, thereby composing a light reception unit 20.

[0018] The angular deviation detector 19 is divided into four photodetection elements 19a to 19d, as shown in Fig. 3, and electric signals from the respective elements are supplied to the load impedances 21a to 21d. Further, each of these electric signals is split into two, which are supplied through band-pass filter 22a to 22d and band-pass filter 23a to 23d to corresponding detectors 24a to 24d and 25a to 25d. An output of the angle deviation detector 19 is connected to a system control unit 26 having an external condition setting device and to a servo system loop filter 27, and an output of the system control unit 26 is connected to the servo system loop filter 27, to an amplifier 28, and to a beam size variable means 29 for driving the lens system 14. Further, an output of the amplifier 28 is connected through an optical-axis angle adjustment drive control unit 30 to the optical-axis angle adjustment drive mechanism 16. Further, an output of the servo system loop filter 27 is connected to the amplifier 28.

[0019] The main signal, being the transmission signal, is multiplexed in the multiplexer 11 with the first pilot signal from the pilot signal generator 12, the thus multiplexed signal is converted into a first light signal (first light beam) in the electro-optical converter 13, the beam size variable means 29 for changing the beam size of the transmission beam moves the lens system 14 along the optical axis to control the beam size so that a predetermined beam size may be achieved at a position where a party apparatus is located, and the light signal is transmitted through the polarizing beam splitter 15 and optical-axis angle adjustment drive mechanism 16.

[0020] On the other hand, a second light signal (second light beam) sent from the party apparatus and including a second pilot signal is guided through the optical-axis angle adjustment drive mechanism 16 and polarizing beam splitter 15 to the light reception unit 20, where it is split by the beam splitter 17 into two beams traveling toward the main signal detector 18 and toward the angle deviation detector 19. The main signal detector 18 receives the main signal to output the reception signal, while the angle deviation detector 19 receives the second pilot signal sent from the party apparatus by each of the four segmental detection elements 19a to

19d, which generate electric currents corresponding to light intensities of received light. These current signals are converted into voltage signals (second electric signals) in the load impedances 21a to 21d. Each of these voltage signals is split into two signals, the bands of which are limited by the band-pass filter 22a to 22d and band-pass filter 23a to 23d. After that, the voltage signals are detected by the associated detectors 24a to 24d and 25a to 25d to become detection signals Va to Vd and Va' to Vd' corresponding to respective receiving-light levels.

[0021] As shown in Fig. 4, the detection signals Va to Vd are used to detect the angular deviation between the receiving light and the optical axis of the light reception unit 20. Further, the system control unit 26 controls the servo system loop filter 27, amplifier 28, and beam variable means 29 to send a signal to the optical-axis angle adjustment drive control unit 30, whereby the optical-axis angle adjustment drive control unit 30 controls the optical-axis angle adjustment drive mechanism 16 to correct the angular deviation. In the apparatus the optical axis of the light transmission unit 10 is preliminarily aligned with the optical axis of the light reception unit 20. Thus, once the angular deviation is corrected between the receiving light from the party apparatus and the light reception unit 20, the transmission light can be sent on the same optical axis as the receiving light is transmitted from the party apparatus. Two-way optical space communication as being always stable becomes possible by the above operation between the apparatus opposed to each other.

[0022] Fig. 5 shows the band-pass filters 22a to 22d, 23a to 23d, in which, letting fO be the frequency of the second pilot signal transmitted from the party apparatus, the band-pass filters 22a to 22d include the frequency fO in the pass region and the band-pass filters 23a to 23d do not include the frequency fO in the pass region. It is noted here that the pass regions of the band-pass filters 22a to 22d and band-pass filters 23a to 23d do not have to be continuously arranged. They may be set apart from each other or may overlap with each other. Further, one pass region may be included completely in the other. The point is whether the pass region includes the frequency fO or not.

[0023] The shot noise due to the background light can be considered to have almost uniform noise power per unit frequency within a certain frequency range. For example, if the band widths of the band-pass filters 22a, 23a are known, the S/N ratio of the detection signal Va including the frequency fO can be calculated based on the detection signals Va and Va'. This is because the detection signal Va is a signal in which the shot noise is multiplexed with the second pilot signal and the detection signal Va' is a signal which represents only the shot noise. The same means can also be used to recognize the noise light when only the noise light is incident without incidence of the second pilot signal. When absence of incidence of the second pilot signal is recognized from the detection signals Va to Vd and Va' to Vd' and even if the values of the detection signals Va to Vd are not less than the low limiting value set, the all values are set to the lower limiting value.

[0024] If in spite of reception of the second pilot signal the system control unit 26 determines from the detection signals Va to Vd and Va' to Vd' that the level of the background light is too high to accurately perform the angle correction of the receiving light because the strong background light could degrade the S/N ratio of the second pilot signal used in detecting the angular deviation, the system control unit 26 lowers the cut-off frequency of the servo system loop filter 27 for angle correction, thereby performing the angle correction of the receiving light without practical trouble by controlling the optical-axis angle adjustment drive mechanism 16. Namely, when it is considered that there is no extremely quick vibration because of good installation conditions of apparatus, the S/N ratio of the second pilot signal used in detecting the angular deviation can be improved by lowering the frequency characteristics of the servo system loop filter 27.

[0025] If the system control unit 26 determines from the detection signals Va to Vd and Va' to Vd' that accurate angle correction of the receiving light cannot be done and if the installation conditions do not allow the frequency characteristics of the servo system loop filter 27 to be lowered, the system control unit 26 decreases the servo system loop gain as victimizing the accuracy of angle correction and further controls the beam variable means 29 to enlarge the size of the transmission beam to the party apparatus opposed in order to compensate for the decrease of the loop gain. This results in decreasing a margin for attenuation of light signal on the transmission path. However, an increase of the level of incidence of the background light due to the direct rays of the sun implies low attenuation of light on the transmission path, and the same can be applied to the light signal on the transmission path, thus causing no practical trouble. If the background light decreases below the permissible level thereof in a normal system condition, the control unit 26 returns the system to the normal condition.

[0026] The cut-off frequency and the loop gain of the servo system loop filter 27 for controlling the angle of the receiving optical system can be arranged as to be variable in such a manner that the detection signals Va to Vd are subjected to analog-digital conversion, the digital signals are taken into a CPU in the control unit 26, and they are made variable on software or by using an analog circuit. Further, the size of the transmission beam to the party apparatus opposed can be made variable by horizontally moving the lens system 14 disposed between the electro-optical converter 13 and the polarizing beam splitter 15 along the optical axis, and the control of movement of the lens system is executed by the CPU in the control unit 26.

[0027] As detailed above, the optical space commu-

nication apparatus according to the present invention is arranged in such a manner that the angular deviation detecting unit of receiving light can independently detect the receiving level of the pilot signal and the receiving level of shot noise due to the background light, whereby the apparatus can perform the angle correction of receiving light without practical trouble even with an extreme increase of the shot noise due to the background light.

Claims

1. An optical space communication apparatus for performing communication by propagating a light signal in a free space, comprising:

   multiplexing means for multiplexing a first pilot signal with a transmission signal;
   first converting means for converting a first electric signal from said multiplexing means into a first light signal;
   a transmitting optical system for transmitting said first light signal to a party apparatus;
   a receiving optical system for receiving a second light signal including a second pilot signal, having been transmitted from said party apparatus;
   second converting means for converting said second light signal into a second electric signal;
   a first band-pass filter having a pass region comprising a frequency of said second pilot signal;
   first detecting means for detecting said second electric signal having passed through said first band-pass filter;
   adjusting means for adjusting an angle of said receiving optical system; and
   control means for controlling said adjusting means;

   characterized by

   a second band-pass filter having a pass region not including the frequency of said second pilot signal;
   second detecting means for detecting said second electric signal having passed through said second band-pass filter; and
   frequency variable means for making variable a cut-off frequency of a servo system loop filter for said control means, based on signals from said first detecting means and said second detecting means.

2. The apparatus according to claim 1, further comprising:

   gain variable means for making a servo system loop gain for said control means variable, based on the signals from said first detecting means and said second detecting means; and
   beam size variable means for making a transmission beam size of said first light signal variable, based on the signals from said first detecting means and said second detecting means.

3. The apparatus according to claim 1, wherein if control of adjustment of the angle by said control means cannot be done accurately, said frequency variable means lowers the cut-off frequency of the servo system loop filter for said control means.

4. The apparatus according to claim 2, wherein if variable operation of the frequency by said frequency variable means cannot be done, said gain variable means decreases the servo system loop gain for said control means and said beam size variable means enlarges the transmission beam size of said first light signal.

5. The apparatus according to any one of claims 1 to 4, wherein said receiving optical system is adapted for splitting a light signal having been transmitted from said party apparatus into a predetermined light signal and said second light signal comprising a second pilot signal; and detection means are provided for detecting a main signal from said predetermined light signal.

6. An angle adjusting method of a receiving optical system in an optical space communication system for performing communication by propagating a light signal in a free space, comprising:

   a step of multiplexing a first pilot signal with a transmission signal by multiplexing means;
   a step of converting a first electric signal from said multiplexing means into a first light signal;
   a step of transmitting said first light signal to a party apparatus through a transmitting optical system;
   a step of receiving through a receiving optical system a second light signal comprising a second pilot signal, having been transmitted from said party apparatus;
   a step of converting said second light signal into a second electric signal; a step of detecting by first detecting means said second electric signal having passed through a first band-pass filter having a pass region comprising a frequency of said second pilot signal;

   characterized by

a step of detecting by second detecting means said second electric signal having passed through a second band-pass filter having a pass region not including the frequency of said second pilot signal; and
a step of making variable a cut-off frequency of a servo system loop filter for adjustment of an angle of said receiving optical system, based on signals from said first detecting means and said second detecting means.

7. An angle adjusting method of a receiving optical system in an optical space communication system for performing communication by propagating a light signal in a free space, comprising:

a step of multiplexing a first pilot signal with a transmission signal;
a step of converting a first electric signal from said multiplexing means into a first light signal;
a step of transmitting said first light signal to a party apparatus through a transmitting optical system;
a step of receiving through a receiving optical system a second light signal comprising a second pilot signal, having been transmitted from said party apparatus;
a step of converting said second light signal into a second electric signal;
a step of detecting by first detecting means said second electric signal having passed through a first band-pass filter having a pass region comprising a frequency of said second pilot signal;

characterized by

a step of detecting by second detecting means said second electric signal having passed through a second band-pass filter having a pass region not including the frequency of said second pilot signal;
a step of making variable a servo system loop gain for adjustment of an angle of said receiving optical system, based on signals from said first detecting means and said second detecting means; and a step of making a transmission beam size of said first light signal variable, based on the signals from said first detecting means and said second detecting means.

Patentansprüche

1. Optische Raum-Kommunikationsvorrichtung zum Durchführen einer Nachrichtenübertragung durch Ausbreiten eines Lichtsignals im freien Raum, umfassend:

- eine Multiplex-Einrichtung zum Multiplexen eines ersten Pilotsignals mit einem Sendesignal;
- eine erste Wandlereinrichtung zum Umwandeln eines ersten elektrischen Signals von der Multiplex-Einrichtung in ein erstes Lichtsignal;
- eine Sendeoptik zum Senden des ersten Lichtsignals zu einer Teilnehmervorrichtung;
- eine Empfangsoptik zum Empfangen eines zweiten Lichtsignals, das ein zweites Pilotsignal enthält, und das von der Teilnehmervorrichtung gesendet wurde;
- eine zweite Wandlereinrichtung zum Umwandeln des zweiten Lichtsignals in ein zweites elektrisches Signal;
- ein erstes Bandpaßfilter mit einem Durchlaßbereich, der eine Frequenz des zweiten Pilotsignals enthält;
- eine erste Detektiereinrichtung zum Erfassen des zweiten elektrischen Signals, welches durch das erste Bandpaßfilter hindurchgelangt;
- eine Einstelleinrichtung zum Einstellen eines Winkels der Empfangsoptik; und
- eine Steuereinrichtung zum Steuern der Einstelleinrichtung;

gekennzeichnet durch

- ein zweites Bandpaßfilter mit einem Durchlaßbereich, der die Frequenz des zweiten Pilotsignals nicht enthält;
- eine zweite Detektiereinrichtung zum Erfassen des zweiten elektrischen Signals, welches durch das zweite Bandpaßfilter hindurchgelangt ist; und
- eine Frequenzänderungseinrichtung zum Veränderlich-Machen einer Eckfrequenz eines Servosystem-Schleifenfilters für die Steuereinrichtung, basierend auf Signalen von der ersten Detektiereinrichtung und der zweiten Detektiereinrichtung.

2. Vorrichtung nach Anspruch 1, weiterhin umfassend:

- eine Verstärkungsänderungseinrichtung zum Veränderlich-Machen einer Servosystem-Schleifenverstärkung für die Steuereinrichtung basierend auf den Signalen der ersten und der zweiten Detektiereinrichtung; und
- eine Strahlbündelgrößen-Änderungseinrichtung zum Veränderlich-Machen einer Sendestrahlbündelgröße des ersten Lichtsignals basierend auf den Signalen der ersten und der zweiten Detektiereinrichtung.

3. Vorrichtung nach Anspruch 1, bei der,
wenn die Steuerung der Einstellung des Winkels durch die Steuereinrichtung nicht exakt durchge-

führt werden kann, die Frequenzänderungseinrichtung die Eckfrequenz des Servosystem-Schleifenfilters für die Steuereinrichtung absenkt.

4. Vorrichtung nach Anspruch 2, bei der,
wenn die Frequenzänderung durch die Frequenzänderungseinrichtung nicht vorgenommen werden kann, die Verstärkungsänderungseinrichtung die Servosystem-Schleifenverstärkung für die Steuereinrichtung verringert, und die Strahlbündelgrößen-Änderungseinrichtung die Sendestrahlbündelgröße des ersten Lichtsignals erhöht.

5. Vorrichtung nach einem der Ansprüche 1 bis 4, bei der
die Empfangsoptik dazu ausgebildet ist, ein Lichtsignal, welches von der Teilnehmervorrichtung gesendet wurde, in ein vorbestimmtes Lichtsignal und das ein zweites Pilotsignal enthaltende zweite Lichtsignal aufzutrennen wobei eine Detektiereinrichtung vorgesehen ist, um aus dem vorbestimmten Lichtsignal ein Hauptsignal zu erfassen.

6. Winkeleinstellverfahren für eine Empfangsoptik in einem optischen Raum-Kommunikationssystem zum Durchführen einer Nachrichtenübertragung durch Ausbreiten eines Lichtsignals im freien Raum, umfassend:

- einen Schritt des Multiplexens eines ersten Pilotsignals mit einem Sendesignal durch eine Multiplex-Einrichtung;
- einen Schritt des Umwandelns eines ersten elektrischen Signals von der Multiplex-Einrichtung in ein erstes Lichtsignal;
- einen Schritt des Sendens des ersten Lichtsignals zu einer Teilnehmervorrichtung über eine Sendeoptik;
- einen Schritt des Empfangens eines ein zweites Pilotsignal enthaltenden, von der Teilnehmervorrichtung gesendeten zweiten Lichtsignals mittels einer Empfangsoptik;
- einen Schritt des Umwandelns des zweiten Lichtsignals in ein zweites elektrisches Signal;
- einen Schritt des Erfassens des zweiten elektrischen Signals, welches ein erstes Bandpaßfilter mit einem Durchlaßbereich, der eine Frequenz des zweiten Pilotsignals enthält, hindurchgelangten zweiten elektrischen Signals mit Hilfe einer ersten Detektiereinrichtung;

gekennzeichnet durch

- einen Schritt des Erfassens des zweiten elektrischen Signals, welches durch ein zweites Bandpaßfilter mit einem Durchlaßbereich, der die Frequenz des zweiten Pilotsignals nicht enthält, hindurchgelangt ist, von einer zweiten Detektiereinrichtung; und
- einen Schritt des Veränderlich-Machens einer Eckfrequenz eines Servosystem-Schleifenfilters zur Einstellung eines Winkels der Empfangsoptik basierend auf Signalen der ersten und der zweiten Detektiereinrichtung.

7. Winkeleinstellverfahren für eine Empfangsoptik in einem optischen Raum-Kommunikationssystem zum Durchführen einer Nachrichtenübertragung durch Ausbreiten eines Lichtsignals im freien Raum, umfassend:

- einen Schritt des Multiplexens eines ersten Pilotsignals mit einem Sendesignal;
- einen Schritt des Umwandelns eines ersten elektrischen Signals von der Multiplex-Einrichtung in ein erstes Lichtsignal;
- einen Schritt des Sendens des ersten Lichtsignals zu einer Teilnehmervorrichtung über eine Sendeoptik;
- einen Schritt des Empfangens eines ein zweites Pilotsignal enthaltenden zweiten Lichtsignals, welches von der Teilnehmervorrichtung gesendet wurde, mit einer Empfangsoptik;
- einen Schritt des Umwandelns des zweiten Lichtsignals in ein zweites elektrisches Signal;
- einen Schritt des Nachweisens des zweiten elektrischen Signals, welches durch ein erstes Bandpaßfilter mit einem Durchlaßbereich, der eine Frequenz des zweiten Pilotsignals enthält, hindurchgelangt ist, mittels einer ersten Detektiereinrichtung;

gekennzeichnet durch

- einen Schritt des Erfassens des zweiten elektrischen Signals, welches durch ein zweites Bandpaßfilter mit einem Durchlaßbereich, der die Frequenz des zweiten Pilotsignals nicht enthält, hindurchgelangt ist, mittels einer zweiten Detektiereinrichtung;
- einen Schritt des Veränderlich-Machens einer Servosystem-Schleifenverstärkung zur Einstellung eines Winkels der Empfangsoptik basierend auf Signalen der ersten und der zweiten Detektiereinrichtung; und
- einen Schritt des Veränderlich-Machens einer Sendestrahlbündelgröße des ersten Lichtsignals basierend auf Signalen der ersten und der zweiten Detektiereinrichtung.

Revendications

1. Appareil de communication optique en espace libre pour réaliser des communications par propagation

d'un signal de lumière dans un espace libre, comprenant :

des moyens de multiplexage pour multiplexer un premier signal pilote avec un signal de transmission ;
des premiers moyens de conversion pour convertir un premier signal électrique provenant desdits moyens de multiplexage en un premier signal de lumière ;
un système optique d'émission pour émettre ledit premier signal de lumière vers un appareil correspondant ;
un système optique de réception pour recevoir un second signal de lumière comprenant un second signal pilote ayant été émis par ledit appareil correspondant ;
des seconds moyens de conversion pour convertir ledit second signal de lumière en un second signal électrique ;
un premier filtre passe-bande ayant une région passante comprenant une fréquence dudit second signal pilote ;
des premiers moyens de détection pour détecter ledit second signal électrique ayant passé à travers ledit premier filtre passe-bande ;
des moyens d'ajustement pour ajuster un angle dudit système optique de réception ; et
des moyens de commande pour commander lesdits moyens d'ajustement ;

caractérisé par ;

un second filtre passe-bande ayant une région passante n'incluant pas la fréquence dudit second signal pilote ;
des seconds moyens de détection pour détecter ledit second signal électrique ayant passé à travers ledit second filtre passe-bande ; et
des moyens de variation de fréquence pour rendre variable une fréquence de coupure d'un filtre de boucle d'asservissement pour lesdits moyens de commande, sur la base de signaux provenant desdits premiers moyens de détection et desdits seconds moyens de détection.

2. Appareil selon la revendication 1, comprenant en outre :

des moyens de variation de gain pour rendre variable un gain de boucle d'asservissement pour lesdits moyens de commande, sur la base des signaux provenant desdits premiers moyens de détection et desdits seconds moyens de détection ; et
des moyens de variation de taille de faisceau pour rendre variable une taille de faisceau d'émission dudit premier signal de lumière, sur la base des signaux provenant desdits premiers moyens de détection et desdits seconds moyens de détection.

3. Appareil selon la revendication 1, dans lequel :
si la commande d'ajustement de l'angle qui est réalisée par lesdits moyens de commande ne peut pas être faite avec précision, lesdits moyens de variation de fréquence abaissent la fréquence de coupure du filtre de la boucle d'asservissement pour lesdits moyens de commande.

4. Appareil selon la revendication 2, dans lequel :
si une opération de variation de la fréquence réalisée par lesdits moyens de variation de fréquence ne peut pas être faite, lesdits moyens de variation de gain réduisent le gain de la boucle d'asservissement pour lesdits moyens de commande et lesdits moyens de variation de taille de faisceau augmentent la taille du faisceau d'émission dudit premier signal de lumière.

5. Appareil selon l'une quelconque des revendications 1 à 4, dans lequel ledit système optique de réception est conçu pour séparer un signal de lumière ayant été émis par ledit appareil correspondant en un signal de lumière prédéterminé et ledit second signal de lumière comprenant un second signal pilote ; et des moyens de détection sont prévus pour détecter un signal principal à partir dudit signal de lumière prédéterminé.

6. Procédé d'ajustement d'angle d'un système optique de réception dans un système de communication optique en espace libre pour réaliser des communications par propagation d'un signal de lumière dans un espace libre, comprenant :

une étape de multiplexage d'un premier signal pilote avec un signal d'émission par des moyens de multiplexage ;
une étape de conversion d'un premier signal électrique provenant desdits moyens de multiplexage en un premier signal de lumière ;
une étape d'émission dudit premier signal de lumière vers un appareil correspondant par l'intermédiaire d'un système optique d'émission ;
une étape de réception par l'intermédiaire d'un système optique de réception d'un second signal de lumière comprenant un second signal pilote ayant été émis par ledit appareil correspondant ;
une étape de conversion dudit second signal de lumière en un second signal électrique ;
une étape de détection par des premiers moyens de détection dudit second signal électrique ayant passé à travers un premier filtre passe-bande ayant une région passante com-

prenant une fréquence dudit second signal pilote ;

caractérisé par :

une étape de détection par lesdits seconds moyens de détection dudit second signal électrique ayant passé à travers un second filtre passe-bande ayant une région passante n'incluant pas la fréquence dudit second signal pilote ; et
une étape pour rendre variable une fréquence de coupure d'un filtre d'une boucle d'asservissement pour l'ajustement d'un angle dudit système optique de réception, sur la base de signaux provenant desdits premiers moyens de détection et desdits seconds moyens de détection.

7. Procédé d'ajustement d'angle d'un système optique de réception dans un système de communication optique en espace libre pour réaliser des communications par propagation d'un signal de lumière dans un espace libre, comprenant :

une étape de multiplexage d'un premier signal pilote avec un signal de transmission ;
une étape de conversion d'un premier signal électrique provenant desdits moyens de multiplexage en un premier signal de lumière ;
une étape d'émission dudit premier signal de lumière vers un appareil correspondant par l'intermédiaire d'un système optique d'émission ;
une étape de réception par l'intermédiaire d'un système optique de réception d'un second signal de lumière comprenant un second signal pilote, ayant été émis par ledit appareil correspondant ;
une étape de conversion dudit second signal de lumière en un second signal électrique ;
une étape de détection par lesdits premiers moyens de détection dudit second signal électrique ayant passé à travers un premier filtre passe-bande ayant une région passante comprenant une fréquence dudit second signal pilote ;

caractérisé par :

une étape de détection par des seconds moyens de détection dudit second signal électrique ayant passé à travers un second filtre passe-bande ayant une région passante n'incluant pas la fréquence dudit second signal pilote ;
une étape pour rendre variable un gain d'une boucle d'asservissement pour l'ajustement d'un angle dudit système optique de réception, sur la base de signaux provenant desdits premiers moyens de détection et desdits seconds moyens de détection ; et
une étape pour rendre variable une taille du faisceau d'émission dudit premier signal de lumière, sur la base des signaux provenant desdits premiers moyens de détection et desdits seconds moyens de détection.

FIG. 1

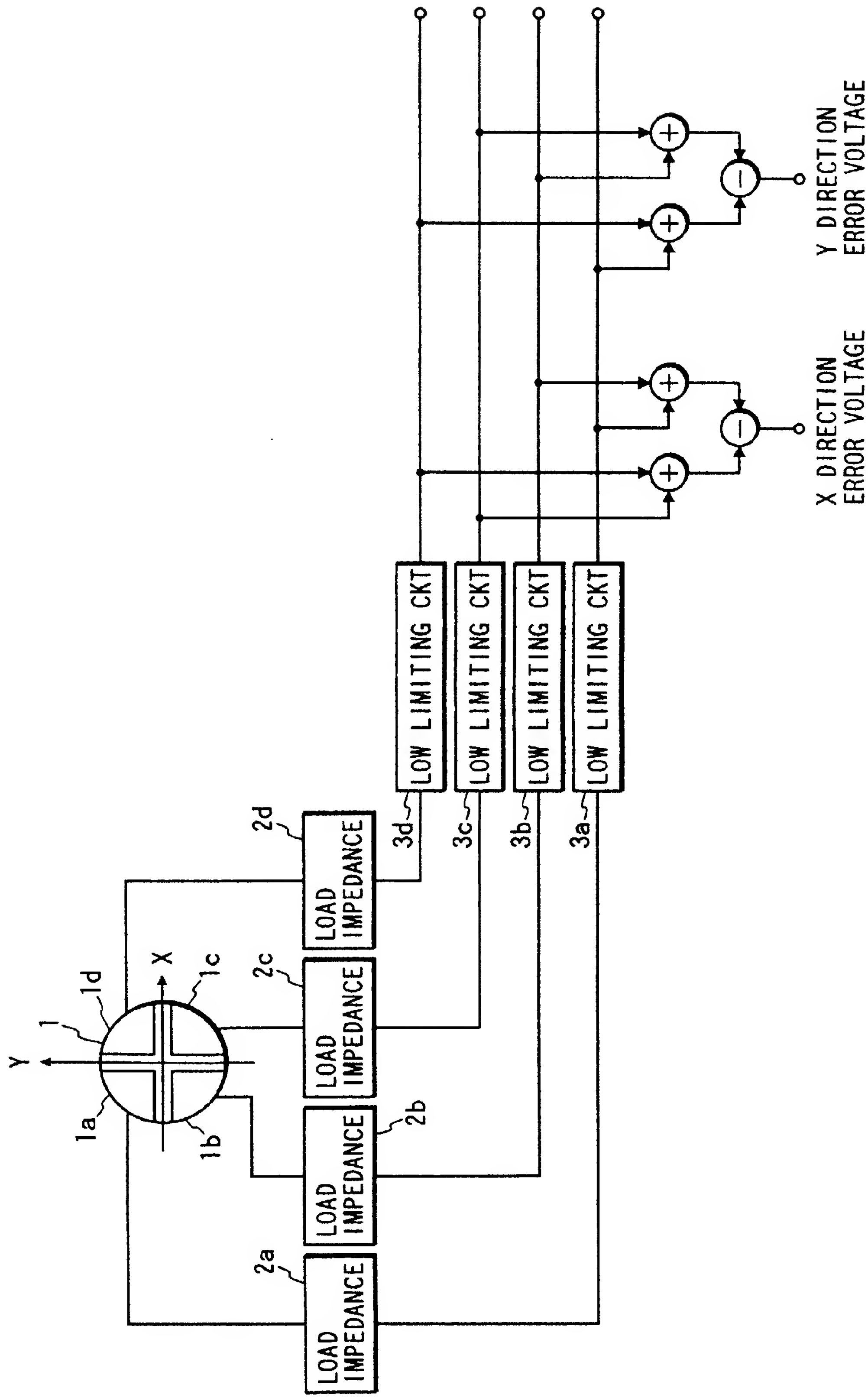

Y
X
1
1a
1b
1c
1d
2a
2b
2c
2d
LOAD IMPEDANCE
LOAD IMPEDANCE
LOAD IMPEDANCE
LOAD IMPEDANCE
3a
3b
3c
3d
LOW LIMITING CKT
LOW LIMITING CKT
LOW LIMITING CKT
LOW LIMITING CKT
X DIRECTION ERROR VOLTAGE
Y DIRECTION ERROR VOLTAGE

FIG. 2

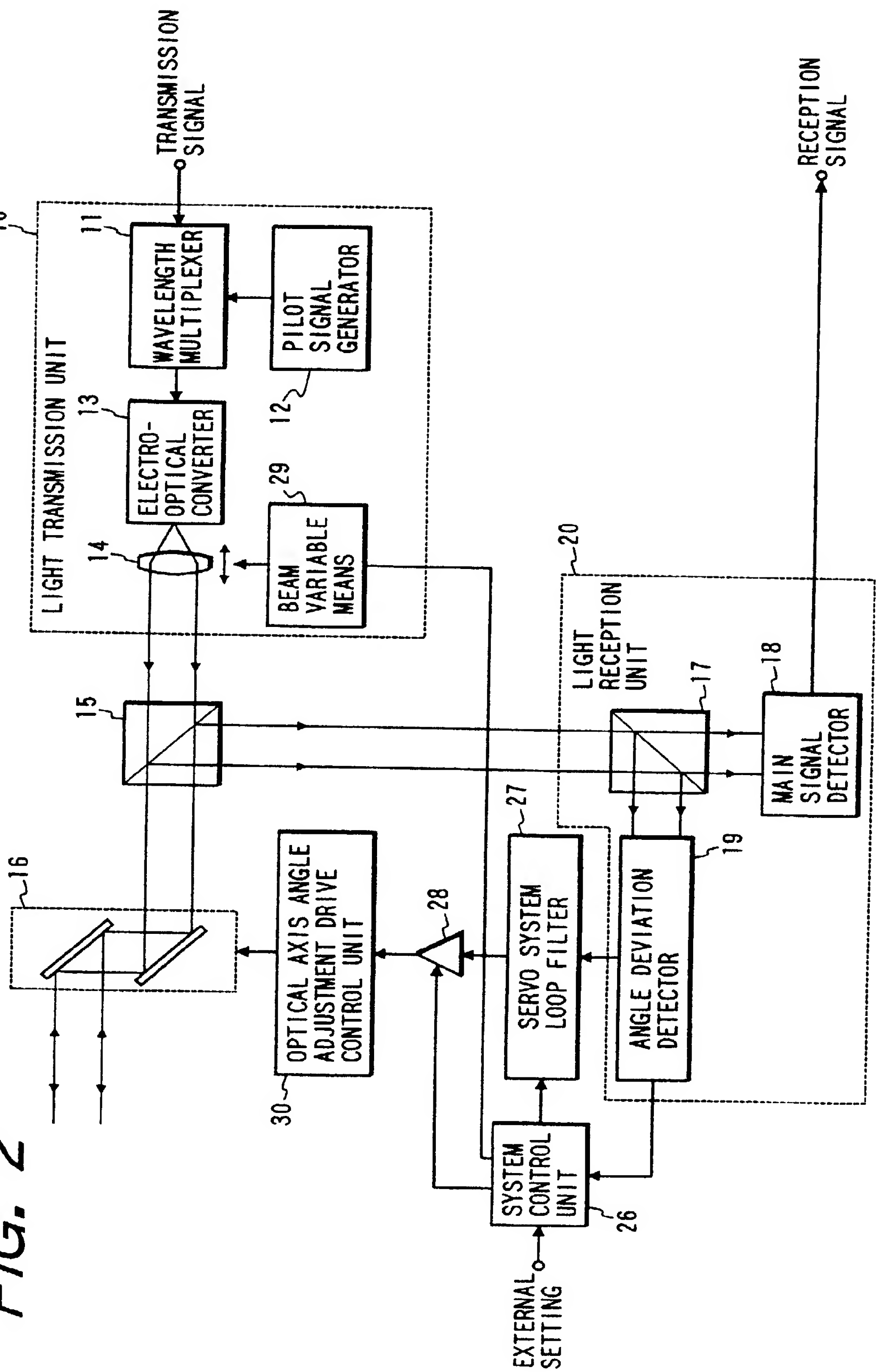

TRANSMISSION SIGNAL
10
LIGHT TRANSMISSION UNIT
11
WAVELENGTH MULTIPLEXER
PILOT SIGNAL GENERATOR
12
13
ELECTRO-OPTICAL CONVERTER
14
29
BEAM VARIABLE MEANS
15
16
20
LIGHT RECEPTION UNIT
17
18
MAIN SIGNAL DETECTOR
RECEPTION SIGNAL
19
ANGLE DEVIATION DETECTOR
27
SERVO SYSTEM LOOP FILTER
28
OPTICAL AXIS ANGLE ADJUSTMENT DRIVE CONTROL UNIT
30
SYSTEM CONTROL UNIT
26
EXTERNAL SETTING

FIG. 3

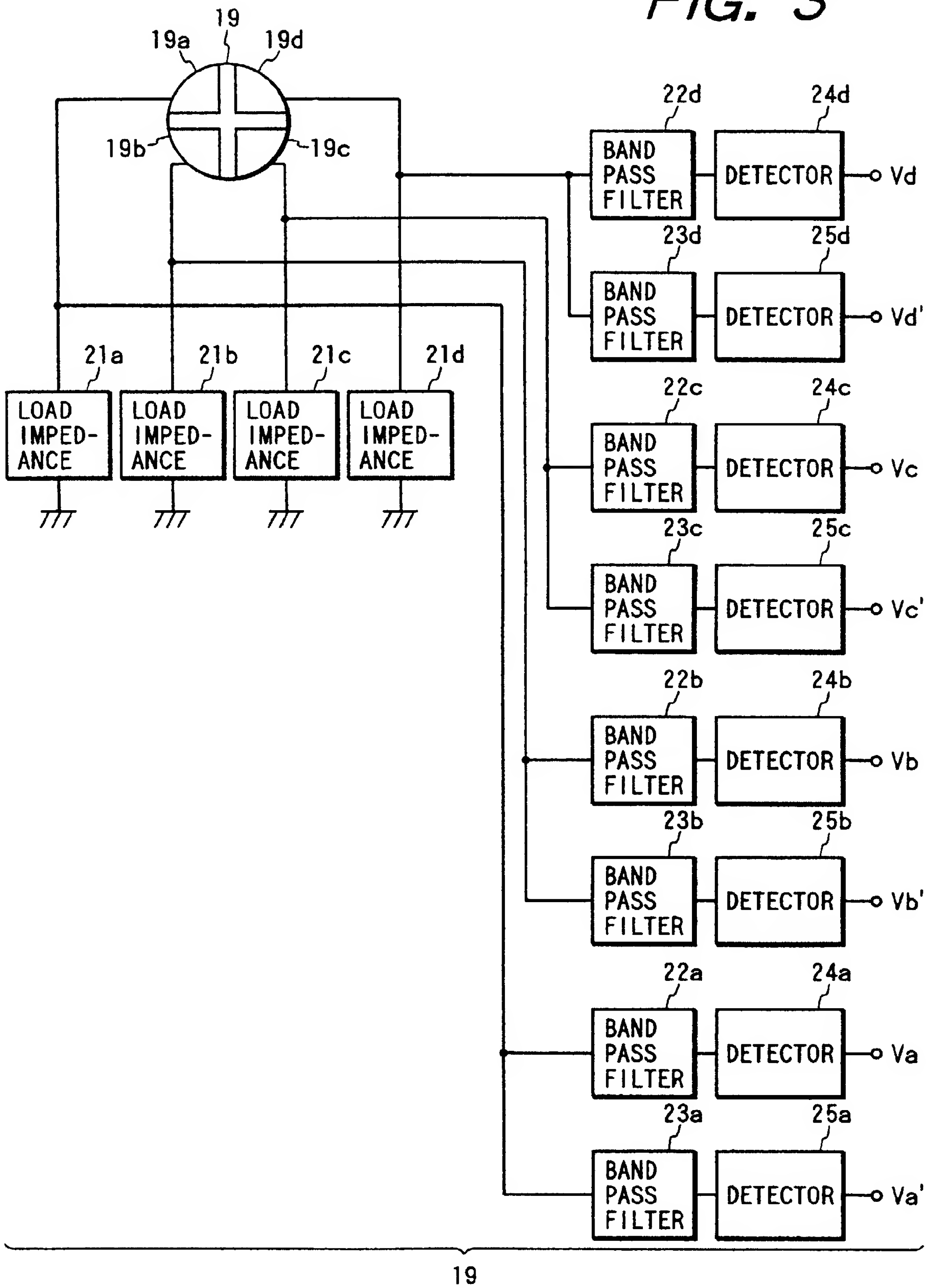

19
19a
19d
19b
19c
22d
24d
BAND PASS FILTER
DETECTOR
Vd
23d
25d
BAND PASS FILTER
DETECTOR
Vd'
21a
21b
21c
21d
LOAD IMPED-ANCE
LOAD IMPED-ANCE
LOAD IMPED-ANCE
LOAD IMPED-ANCE
22c
24c
BAND PASS FILTER
DETECTOR
Vc
23c
25c
BAND PASS FILTER
DETECTOR
Vc'
22b
24b
BAND PASS FILTER
DETECTOR
Vb
23b
25b
BAND PASS FILTER
DETECTOR
Vb'
22a
24a
BAND PASS FILTER
DETECTOR
Va
23a
25a
BAND PASS FILTER
DETECTOR
Va'
19

FIG. 4

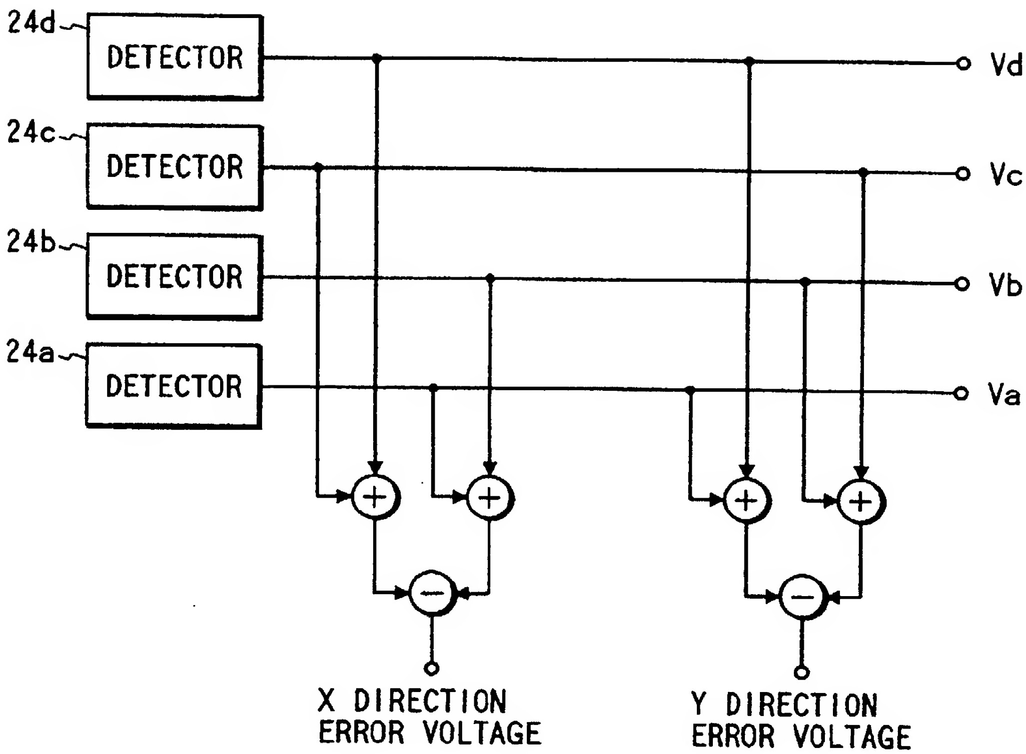
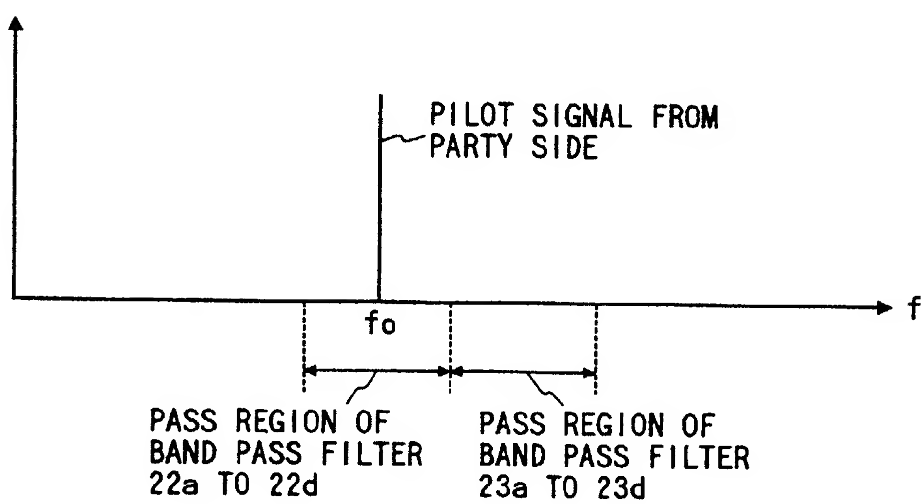

24d
DETECTOR
24c
DETECTOR
24b
DETECTOR
24a
DETECTOR
Vd
Vc
Vb
Va
+
−
X DIRECTION
ERROR VOLTAGE
Y DIRECTION
ERROR VOLTAGE

FIG. 5


PILOT SIGNAL FROM
PARTY SIDE
fo
f
PASS REGION OF
BAND PASS FILTER
22a TO 22d
PASS REGION OF
BAND PASS FILTER
23a TO 23d